EGU26-12781, updated on 06 Jun 2026
https://doi.org/10.5194/egusphere-egu26-12781
EGU General Assembly 2026

A Lagrangian blending of optical flow and ML-based radar precipitation nowcasts

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Recent research and development at Environment and Climate Change Canada has been conducted on improving the current operational radar precipitation nowcasting by transitioning from an optical flow method (Farnebäck smoothed) to machine learning (ML)-based nowcasts. Two ML-based nowcasting models were trained on the Canadian radar composite: RainNet, a convolutional neural network based on the U-Net architecture, and NowcastNet, which combines a Generative Adversarial Network with an Evolution Network to explicitly model precipitation dynamics. Verification of radar precipitation nowcasts revealed that the optimal method depends on both lead time and precipitation threshold. RainNet performed best for low precipitation thresholds (0.1-1 mm/h) at all lead times, highlighting its ability to capture widespread, weak precipitation, while NowcastNet outperformed the others at longer lead times (beyond one hour) and for higher precipitation thresholds (4+ mm/h). Farnebäck smoothed remained the most skillful for nowcasting heavy precipitation (12+ mm/h) during the first hour, likely due to its robust short-term motion estimation.

Building on these results, we propose a Lagrangian blending method that optimally combines the predicted motion paths and the growth and decay of precipitation intensity components of the different nowcasting methods. While optical flow methods assume constant motion and intensity evolution, ML-based methods produce time-varying motion vectors and precipitation intensities, which are explicitly leveraged in the blending framework. For deterministic nowcasts, we apply a bias-correction followed by the blending of both motion paths and intensity, allowing the generation of time-evolving blended motion fields with growth and decay.

We also generate probabilistic nowcasts of precipitation occurrence (0.1 mm/h) and extreme precipitation (50 mm/h) by determining the optimal spatial smoothing for each model and lead time based on the area under the ROC curve. We then calibrate the resulting probabilities using isotonic (i.e. monotonically increasing) regression. Experiments are conducted using both static and dynamically varying weighting strategies for both deterministic and probabilistic radar precipitation nowcasting. The goal is to produce a blended and post-processed nowcast that outperforms each individual method across all lead times and precipitation thresholds.